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A safer, faster, leaner workplace? Technical-maintenance worker perspectives on digital drone technology ‘effects’ in the European steel industry

Dean Stroud  and Martin Weinel 

This paper focuses on technical-maintenance worker perspectives on the insertion of digitised drone technologies in the European steel industry. The industry is aiming for a ‘business model transformation’ by means of digitalisation, which includes the use of drone technologies for maintenance functions. In this paper, we explore on what basis might such workers embrace or resist this new technology. Drawing on data from a project investigating the use of drones for a ‘safer, faster and leaner’ workplace, we employ an analysis of technology ‘effects’ to discuss the risks and benefits to workers of drone technologies (see Orlikowski, Organ. Sci., 3, 1992, 398; Edwards and Ramirez, New Technol. Work Employ., 31, 2016, 99). The insertion and use of drone technology within the industry raises questions for the industry’s highly skilled workers and their representatives on the ‘effect’ of drone innovations on the industry’s existing structures and patterns of work.

Keywords: digital technology, industry 4.0, technological innovations, technology ‘effects’, steel industry.

Introduction

An increasingly discussed feature of work and employment is the emergence of the ‘digital workplace’. For manufacturing specifically, it is often referred to as ‘Industry 4.0’, which emerged from Germany as a central economic and industrial policy in 2011 and has since taken on wider resonance across Europe (Pfeiffer, 2017). Here, production is configured upon digital networking systems and the centrality of ‘big

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data' for 'smart factories', with such developments argued to carry numerous implications for the organisation, structure and experience of manufacturing employment (see Briken *et al*, 2017).

The purpose of this paper is to offer an account of the Industry 4.0 workplace and the 'effects' of a specific piece of digitised robotic technology, that is unmanned aerial vehicles (UAVs) or drones. Specifically, we employ technical-maintenance steelworker perspectives on drones to discuss their 'effect' as a piece of technology and consider the threats they pose to workers, as well as the opportunities they offer. These more highly skilled workers, in the steel industry context, tend to retain more autonomy, discretion and control over their work, but the insertion of digital technological innovation in the advanced manufacturing workplace may well begin to threaten such workers' ability to resist processes of alienation and deskilling (see Frey and Osbourne, 2017).

Set within the context of Pfeifer's (2017) discussion of the emergence of Industry 4.0, we view the relationship between workers and the introduction of digitised drone technology through the lens of Orlikowski's (1992) and Edwards' and Ramirez's (2016) combined (six) dimensions of technology 'effects'. In employing this analytical frame, we ask a research question similar to that posed by Edwards and Ramirez (2016: 99) in their discussion of new technologies in the workplace: '[on what basis might technical-maintenance steelworkers] embrace or resist new [drone] technology'? We thus consider how one category of worker perceives the effect of a specific piece of new technology and the tension between its risks and benefits. Our contribution is to provide a case analysis of (intermediate to high-skilled) worker perspectives on emerging digital technologies and their insertion in the advanced manufacturing workplace, thereby adding to the limited empirical work in this area (Briken *et al*, 2017).

Our data come from a Research Fund for Coal and Steel (RFCS) project investigating the use of drones for identifying leaks from gas pipes and the need for repairs to roofs and chimneys in steel plants in Germany and Italy. Alongside developing new drone and digital sensor technologies, the project aims to explore how drones might enhance occupational health and safety (OHS) (e.g. reducing the need for work at height) and improve productivity (e.g. identifying repairs more quickly and reducing labour costs by 'substituting' workers with drones). The intention is for a safer and more efficient workplace, but one that might intensify work and threaten, for some, to remove it entirely. In what follows we begin by outlining the steel industry context for insertion of the drone technology. Second, we situate our discussion within literatures on the relationship between (digital) technology and work. Third, we give an account of Industry 4.0 and our analytical frame. Research design forms the fourth section of the paper. Thereafter, we discuss the data across three themes, that is i) insertion, ii) work 'effects' and iii) worker representation, before discussion and concluding comments.

The steel industry context

The context for our discussion is the European steel industry, which over past decades has experienced major processes of restructuring. The implications for the workforce have been considerable, despite high levels of worker representation across the sector. Those directly employed to the industry have reduced from 800,000 (EU15) in 1980 to 320,000 (EU28) in 2018, with further losses of 30 per cent anticipated by 2025 (Eurofer, 2018). As numbers have declined, the character of the workforce has changed. It is now a smaller, differently recruited and organised workforce, relying less on routine work and 'factory hand' workers and more on the more highly skilled and qualified (Bacon and Blyton, 2000; Stroud, 2012). We consider this detail important because it establishes the context within which the steel industry workforce experiences processes of innovation.

Not all industry innovation is technological, for example the introduction of team working and high-performance working to the industry during the 1980s and 1990s signalled innovatory efforts to improve productivity and performance at an organisational level (Bacon and Blyton, 2000). Similarly, the focus of many technological innovations is to reduce costs, improve efficiency and remain competitive. Digitalisation is

vaunted as the most recent feature of industry innovation and identified as a means for achieving a 'business model transformation' (Naujok and Stamm, 2017). It is claimed that the industry will increasingly turn towards 3D-printing for spare parts, digitally enhanced tracking and operational systems for improved maintenance functions and the use of drone technologies for generating data on maintenance and production (Naujok and Stamm, 2017). Indeed, the data informing this paper derive from a project that has as its objective the use of digitised drone technology '*to substitute men (sic) in complex and expensive operations... related to the monitoring, maintenance and safety of steel plant infrastructures*', which fits with industry efforts to digitalise operations and innovate for efficiency.

Drones, technology and work

Essentially, drones are flying robots and can be controlled remotely or operate autonomously, with the latter not currently permitted by EU regulations. Drone use is highly regulated within the EU and licences are required for commercial use, but regulations are constantly evolving. The latter reflects the continuing development of the technology and, moreover, the European Commission's (EC) support for the development of the UAV industry; the objective is for the creation of 150,000 drone-related jobs by 2050 (European Parliament, 2018). Drone use is certainly expanding within a range of sectors, for example in construction there are experiments with monitoring, inspection and maintenance (Bogue, 2018) and in retail Amazon has trialled parcel delivery (Hern, 2016).

Drones can be employed in a variety of ways: for monitoring, inspection and maintenance purposes, but also for delivering materials and equipment and applying paints and chemicals. A common feature of their use is the capturing of images (e.g. photographs, video, thermal and infrared), and this has raised questions about data protection and surveillance at work (Ball, 2010). As it is, current data protection regulations at EU and member state level offer some protection for workers, as do firm specific negotiated agreements involving trade unions and works councils (as within our research sites). But, their use, particularly when fitted with digitalised data gathering sensor and camera technologies and the (individuated production) data collection and 'dataveillance' (Lupton, 2016) they allow, presents new challenges for the regulation of work and employment.

Such technological developments give rise to new debates, which are concerned with the 'digital workplace' and workers' acceptance of (or resistance to) technologies that threaten fundamental changes to the nature of work. However, as Howcraft and Taylor (2014) note, in many ways these debates rehearse old dilemmas and perennial concerns on the relationship between work and technology. Two opposing perspectives have commonly delineated this relationship, which have special resonance for this paper's analysis and begin to inform the approach we take to discussing technology 'effects'. The first perspective, associated with Blauner (1964) and others, prioritises technology as an objective and external force inserted in the workplace, determining of the organisational aspects of work and affording an industry its distinctive character: for the steel industry, its blast furnaces and rolling mills.

A second perspective emerges out of sociological efforts to counter such technological determinism, and to bring society back into dialogue with technology and understand its effects as socially and politically variable (Gallie, 1978). Labour process theory, for example, discusses how the relations of power and control are critical to the development, selection and deployment of workplace technology and the seemingly irresistible logic of efficiency and productivity (Braverman, 1974). However, as MacKenzie *et al.* (2017) note, the work of Braverman and other labour process scholars is also characterised by some as determinist, for example social constructivists. Certainly the accusation might be that digital technology is discussed in determining ways, with the inevitability of more highly rewarding work for some (Brynjolfsson and McAfee, 2014), technologically induced unemployment for others (Frey and Osborne, 2017; Neufeind *et al.*, 2018) and, perhaps, the end of work entirely (Spencer, 2018).

Wacjman (2018: 168) questions this ‘inevitability’ and, in particular, ‘the widespread assumption that digital technologies... [are making us]... ‘mere hostages to the accelerating drive of machines’. Indeed, the aim of the RFCS project is to employ digitised ‘machines’ to accelerate maintenance functions, but there is no temporal logic inherent in digital technologies. The broader assessment is that digital technologies may well transform ‘how we work, live and communicate’, but they are not neutral, value-free tools that simply drive changes in society... but inherently social... crystallisations of society’ (Wacjman, 2018: 169–171). With such sentiments we agree, but at the same time our focus on ‘technology effects’ gives a level of primacy to technology that brings accusations of determinism (Edwards and Ramirez, 2016). We are mindful, however, of technologically determinist predictions, and that any analysis of ‘the future role of the digital in capitalism [must] embrace an understanding of varied contexts, power relations, choices and decision structures and the capacity for resistance’ (Thompson and Briken, 2017: 258).

Thus, when asking about the effects of technology, like Edwards and Ramirez, 2016: 100–101), we position it as an external force, but one that is shaped by economic and political forces and with impacts moderated by human actors and organisational contexts, and in this way we ascribe to something more of a ‘soft’ determinism (Orlikowski, 1992: 400). We draw parallels with MacKenzie *et al.* (2017: 736). For the latter, in adopting an ‘affordances perspective’ to discuss digital technology and the occupational identity of telecommunications engineers, there is a reconciling of structure and agency that counters accusations of technological determinism. It is an account that recognises the distinct features and characteristics of technology and the ‘affordance’ of opportunities and possibilities for action that derive from the skilled worker’s engagement with the technical object (MacKenzie *et al.*, 2017: 736). In similar ways, we draw on an analysis of technological ‘effects’, to foreground the perspectives of technical-maintenance steelworkers on the dis/empowering capacities of drone technology and its effects on the material realities of work and employment.

Industry 4.0 and the ‘effects’ of digital technology

As a term, Industry 4.0 aims to capture the rise or revolution in new levels of technological developments within manufacturing. However, as a ‘newly emerging global production regime’, Sabine Pfeiffer (2017: 23) asks questions about the powers and interests involved in its creation. Pfeiffer employs Burawoy’s (1985) analysis of the ‘politics of production’ to argue that Industry 4.0 does not, in fact, receive its legitimacy from ‘new technical possibilities but rather from economic ‘exigencies’ as identified by economic elites’ (2017:26). The accusation is that Industry 4.0 is a discourse focused on campaigning to change the way we work and obtain worker consent and acceptance of technological change (Pfeiffer, 2017: 33). Pfeiffer’s concern is with the emergence of a ‘digital despotism’, which can be observed in the way Industry 4.0 innovations are employed by powerful actors (i.e. corporations, nation states and regional and global institutions) to build control.

It is in Pfeiffer’s analysis of Industry 4.0 that we begin to identify a foundation for the way new technology ‘effects’ within advanced manufacturing contexts might be discussed. Our concern, from a worker’s perspective, is to explore the tension between what Pfeiffer identifies as the ‘role of (drone) technology’ as ‘digitalised artefacts of advancement’, that is presenting new opportunities for growth, decent work and ‘potential [as] instruments of collective solidarity’ on the one hand, a potential that Pfeiffer questions, and the potential for drone use as ‘instruments of atomisation and control’, on the other (2017: 35–36). Edwards and Ramirez (2016: 101) similarly note workers’ interest in ‘the forces of production because this potentially creates more and better jobs’ (i.e. decent work and, thus, benefits), and contrasts this with the ‘tendency in capitalism towards the use of technology to reduce workers’ control of the process of production’, by coercion or more direct means (i.e. risks).

There is a long history of argument here, with classic labour process theory noting management’s propensity to deploy technology in ways that consolidates control,

deskilling workers and alienating them from their work and the organisation of production (Braverman, 1974). But later works challenge such perspectives, giving greater scope for workers, afforded by the skills and knowledge they possess, to limit management control over work and the insertion of new technologies (Wood, 1982). Other assessments of technological change and work organisation suggest a polarisation of skill requirements, and concomitant differences in the affordance of workplace discretion (Gallie, 1991). Similar outcomes are anticipated of digitalisation and Industry 4.0, with higher skilled workers forecast to gain greater control, discretion and autonomy over their work and the way it is organised, including with regard to the use and deployment of technology, whereas intermediate and lower grades might find themselves replaced by technology (Brynjolfsson and McAfee, 2014; Frey and Osborne, 2017). Pfeiffer (2017: 21–41), however, imagines little difference in the emerging fortunes of different categories of industrial worker, with new manufacturing technologies promoting rationalisation, standardisation and deskilling, culminating in a wider workplace malaise, that is ‘digital despotism’.

It is with these discussions in mind that we repurpose the question posed by Paul Edwards and Paulina Ramirez on ‘technology effects’ to ask: on what basis might high-skilled technical-maintenance steelworkers embrace or resist new drone technology? To address this question, we draw on Edwards’ and Ramirez’s (2016) analytical frame of technology effects, which takes as its foundation Wanda Orlikowski’s (1992: 398) theoretical model for examining the interaction between technology and organisations, and the insights it provides for understanding technology effects amid ‘the limits and opportunities of human choice, technology development and use, and organisational design’. Orlikowski discusses three effects: (i) intended and unintended effects, (ii) direct and indirect effects, and (iii) reconstitution in use, and; in development of this work Edwards and Ramirez identify a further three dimensions: (iv) immanence of effect, (v) degree of success, and (vi) degree of discontinuity). For reasons of space, we do not provide a detailed discussion of the dimensions but instead draw upon Edwards’ and Ramirez’s application of them to Industry 4.0 to illustrate the essential features (2016: 110–111).

Edwards and Ramirez suggest, more broadly, of the dimensions of ‘effect’ that they might be used to inform workers and their representatives’ response to new technologies. This suggestion, it might be argued, has a particular resonance for Industry 4.0 technology, which will differ significantly from the technology it replaces, i.e. its *discontinuity* and that it introduces highly disruptive innovations in areas of production. Of *immanence* and that inscribed within technology to produce certain outcomes, digital technology may reduce physical strain but increase scope for control and monitoring. *Degree of success* is framed by the different interests involved (e.g. management, workers) in decisions on technology’s adoption and use, including social (i.e. negotiation of adoption) and technological (i.e. the efficacy of the technology) aspects. For Industry 4.0, this speaks to how adoption is determined by political and economic arguments (cf. Pfeiffer, 2017): ‘Economically, it offers a means of accumulation for capital, hence perhaps the eagerness of some firms for it. Politically... it offers a vision of a manufacturing renaissance and a means to prevent the exodus of jobs from the advanced economies’ (Edwards and Ramirez, 2016: 110).

The above Industry 4.0 ‘effects’ are discussed as *direct* and *intended effects*, that is effects that refer to the technology’s purpose, for example introducing technology to reduce physical strain is a *direct* and *intended* effect. A *direct effect* can also include any *unintended effect*, for example heightened capacity for monitoring of workers might be a *direct but unintended effect*, particularly where *reconstitution in use* is added, that is where the technology of production is constituted by management or workers in new ways. It is suggested that the manufacturing flexibility of Industry 4.0 technology will mean high levels of *reconstitution*. What is also suggested of Industry 4.0 technologies is that wider *indirect effects* might emerge, such as the greater likelihood of precarious work (e.g. crowd workers) and new technologies changing the structure of jobs and thus the balance of costs and benefits to workers. Edwards’ and Ramirez’s (2016) observations of Industry 4.0 are quite general, but in what follows we employ the six dimensions as an

analytical frame to focus on the potential ‘effects’ of a particular piece of Industry 4.0 technology, that is drones, from the perspective of what are intermediate to highly skilled technical-maintenance workers, and provide an account of digital technology insertion within a specific and highly collectivised manufacturing industry context.

The research

The data informing this paper are from a RFCS project exploring the potential for drone use in the steel industry, focusing on roof and chimney inspection and monitoring in Italy (*SteelCo.IT*) and gas pipe inspection and monitoring in Germany (*SteelCo.DE*). The choice of each site reflects the project partnership composition. Each site visited is of comparable size, employs the same production processes and has near equivalent production capacity. *SteelCo.DE* directly employs 13,500 people. Most of our interviewees worked within its Technology, Service and Energy (TSE) section, which has overall responsibility for gas pipelines, with two others employed in a near-by plant belonging to the same company and two persons from the Human Resources. *SteelCo.IT* directly employs in the region of 12,000 workers, with our participants working in a range of different roles—systems and maintenance engineering and roof maintenance—within various sections of the plant: roof repair, galvanising production and the cold rolling mill.

Our work on the project was to explore the impact on workers of drone use in two ways:

1. *Social requirements*, for example safety and surveillance and risk and harm arising from drone activity, including the regulatory and ethical implications of being observed at work and the risk arising from new technologies (e.g. job losses and occupational safety).
2. *Impact on work activities*, for example what changes to steelworkers’ work might arise from introducing drones? for example new means of inspecting roofs and new forms of data.

We conducted several hours of group interviews during two-day (Italy) and three-day (Germany) visits. Tours of the plants allowed us to directly observe some of the contexts for drone deployment. The interviewees were chosen by ‘gatekeepers’, that is section managers at each site—the managers having first been informed of the purpose of the project.

The selection of the sample by section managers at each site has clear implications for the generation of data and what inferences might be drawn. However, gaining access to the sites would not have been possible without agreement of each plants’ senior management and, in Germany, the Works Council. Okumus *et al.* (2007) discuss such dilemmas and the use of gatekeepers and selection bias, particularly when ‘getting in’ organisations and ‘getting on’ to discuss sensitive topics—as was the case here (e.g. the potential substitution of workers with technology). Sometimes it is not possible to systematically select participants and the autonomy of the research is threatened, but gatekeepers can also act as facilitators, as much as barriers, and the selection of research participants was extensively discussed and negotiated utilising both Skype and face-to-face meetings. Here, we were able to set out the aims of the project and discuss with the gatekeepers who should be interviewed, with their more intimate knowledge of operations informing discussion. The outcome was a focus on intermediate to high-skilled technical-maintenance workers as those most likely to be involved with/affected by drones. The omission of production workers whose work might also be detrimentally affected by drone technologies means that caution should be exercised regarding any wider claims.

Of note is that in Italy we were explicitly denied access to trade union representatives or officials. As such, we spoke to trade union members and they voiced their views (not as trade unions members *per se*, but as workers involved in the processes

Table 1. List of interviews

Case site	Drone inspection use	Interviews	Sections covered	Professions covered	Position covered
SteelCo.IT	Roof Chimney	4 groups 12 workers	<ul style="list-style-type: none"> • Galvanising • Cold rolling • Steel shop 	<ul style="list-style-type: none"> • Roofers • Systems engineers • Maintenance engineers 	<ul style="list-style-type: none"> • Section leaders • Team leaders • Operators
SteelCo.DE	Gas pipe	5 groups 13 workers	<ul style="list-style-type: none"> • Roof inspection • Works Council • Human Resources • Occupational Health • Service Division • Operators 	<ul style="list-style-type: none"> • Maintenance engineers • Operators • Human Resources 	<ul style="list-style-type: none"> • Team leaders • Section leaders • Operators • HR Management

under investigation who happened to be members of a trade union). Interviews in Germany included members of the Works Council and we spoke to trade union members, but it was not thought necessary by those organising the interviews to involve trade union representatives. The important difference here is in the relationship between management and unions at each site, which was regarded by our contacts as 'difficult' at the site in Italy. By difficult, it is that the plant has long been under threat of closure (or acquisition, which a year later materialised) and this created tensions between management and the site unions. Overall, there is a greater degree of confidence in the SteelCo.DE data, which through the Works Council's direct involvement ensured a more balanced perspective when compared to the Italy data.

Table 1 lists the interviews completed, which were organised as group interviews. Our interviewees were highly experienced workers, all male bar one HR manager, qualified from intermediate to high level, and aged between mid-30s to late 50s. Interviews were conducted on-site by two researchers—using an interpreter where necessary. Each interview lasted between one and two hours, allowing detailed data to be collected and we also cross-checked information with those organising the interviews. Interviews were recorded, fully transcribed and, if necessary, translated. Important in the process of analysis was opening-up the themes of the study, as a way of focusing on and understanding the worker perspectives on the insertion of digital innovations. The analysis comprised reading and re-reading of transcripts drawing out themes reflecting the project remit, as specified above. Overall, we explored complex arrangements, but gained clarity of understanding through our engagements as researchers with those employed at the sites visited.

Steelworker perspectives on drone use

In this section, we discuss our interviewees' perspectives and observations on drone technology and the potential 'effects' of its insertion across three thematic sub-sections. We asked our participants to speculate on the 'effects' of inserting drones, for monitoring purposes primarily but the interviewees discussed their wider uses too, and how they might fit with current ways of working and what risks and benefits to their work and employment they might carry.

Inserting drones in the steel industry

At both companies, organisational restructuring processes have occurred in the recent past and 'flat teams' have been introduced as basic organisational units to reduce hierarchies and promote high-performance working (see Bacon and Blyton, 2000). The focus on organisational considerations is relevant because they allow us to consider how drones might be inserted into existing plant structures and the subsequent 'effects' on working arrangements. On this, our participants in Germany, envisaged three scenarios: (i) the integration of drone technology within existing teams; (ii) the creation of a specialist drone unit; and (iii) the outsourcing of expertise, with the overriding view that:

We would have to create a team of experts here that has the relevant capacity.... I cannot see a situation where every section or team has their own drone...

(Service Division, Maintenance Engineer, Team Leader, SteelCo.DE)

The interviewees at SteelCo.IT were more inclined towards training workers for drone use within separate sections, rather than a centralised drone operation team or outsourced expertise, but overall no immediate organisational challenges were identified at either plant on the insertion of drones into current work arrangements.

Such perspectives reflect the way team working has been introduced within each plant, and the organisational flexibility and autonomous (and more highly skilled)

workgroups, aimed at increased productivity and innovation performance, that now define work and employment within the sector (Bacon and Blyton, 2000; Stroud, 2012). Any mention of outsourcing, for example Germany, was more of a cost issue and buffer against work fluctuations, which reflects some scepticism that drone use (by individual teams) would be sufficient to necessitate the associated (training and hardware) investment. The preference for a separate team or incorporation within existing teams is a comment on how drone use is imagined for optimal use within each plant, but the disruptive ‘effect’ (or *discontinuity*) of the technology on immediate working arrangements and work tasks is viewed to be minimal.

Indeed, at both plants the functional flexibility of the teams means that the introduction of drones would only replace inspection tasks, which constitutes a limited part of overall work: ‘inspection is just part of the job, not the whole job’ [Galvanising, Maintenance Engineer, Section Leader, SteelCo.IT]. There is, moreover, little fear of technologically induced unemployment (i.e. substitution), as a *direct effect* of drone technology:

There would be no change in the numbers of men needed, the repair work still has to be done... it would just save their time in going to inspect and monitor.... Repair work is a manual job, a human job – drones can’t do it.

(Roof Inspection, Roofer, Team Leader, SteelCo.IT)

Our interviewees remain quite sanguine about the ‘effects’ of drone technologies and the threat of disruption deriving from their insertion, including to jobs. Job loss is forecast to be a feature of steel industry digitalisation, mostly for routine manual workers, as it is from processes of digitalisation more generally (Naujok and Stamm, 2017; Frey and Osborne, 2017). And ‘substituting workers’ with drones in steel industry operations, as a specific remit of the RFCS project, speaks directly to those fears. However, whilst interviewees across both plants identified that a *direct effect* of inserting drone technology creates potential for ‘substituting’ one group of workers, that is scaffolders—which is mainly an outsourced task and lesser skilled routine work in the steel industry context—it was not viewed as a credible proposition for these technical-maintenance workers.

Our interviewees speculated that job losses are unlikely to transpire for both them and scaffolders (directly employed and/or contracted), and instead speculated that drones might present a case for further recruitment. On scaffolding work specifically, it is noted that it is widely used across each plant for different activities and, at both sites, there are currently insufficient numbers of directly employed scaffolders to carry out all the work necessary. The predominant view at both plants is that the volume of maintenance work means that drones will merely allow for leakages (in chimneys, roofs and pipes) to be identified more quickly (as an *intended effect*) and generate greater volumes of work (for both scaffolders and maintenance workers). Far from workers being substituted, the *indirect effect* of the drone technology is to create more work and, without the greater investment in staff that our interviewees argue would be necessary, create the conditions for intensified labour. It is, however, difficult to imagine an already overstretched workforce being given new resources for recruitment, particularly if they are to be expended on new digital technologies (see Neef *et al.*, 2018). Hence, drones might not lead to job losses and the predicted technology induced unemployment of Industry 4.0, but of this digital technology there is potential for greater work intensity, the corollary of which has long been shown to be greater stress, greater risk of injury, and greater mental and physical exhaustion (Marglin, 1974).

Our interviewees in Italy commented that there is currently too much work and too few workers, but also that should workers be freed up from roof inspections by drones (as a *direct effect*), other tasks could easily be found and perhaps allow for greater productivity:

There are so many things to do, it wouldn’t be a problem to find him something else to do

(Galvanising, Maintenance Engineer, Section Leader, SteelCo.IT)

Similarly, at SteelCo.DE, interviewees imagined that drone use would increase the speed of monitoring pipelines and free-up workers—a *direct* and *intended effect*. However, our interviewees were also aware that the increased speed of monitoring (and thus greater efficiency) would mainly be attributed to separating the analysis of leaks from the actual inspection practice (i.e. walking along pipelines). These processes would normally be conducted concurrently, with the result that:

...far more information [will be collected], and this means that it has to be analysed. Which means that we will need human capacity to do the analysis of all the additional information.

(Works Council, Operator, Team Leader, SteelCo.DE)

Hence, the separation of the inspection process and the analysis of the data generated creates a *discontinuity* from previous practice and without more investment, or asking more of workers (i.e. work intensification), drones are likely to create the *direct* but *unintended effect* of extending and slowing, rather than speeding, the monitoring process—with the consequence that anticipated efficiency gains are likely to be negated. Plant level regulations similarly incur such efforts—at SteelCo.DE, for example, safety regulations specify that two workers must always conduct pipe monitoring, which is current practice, with or without drones. Regulations thus become an inscribed part of the technology, thereby extending Edwards' and Ramirez's (2016) *immanence of effect* beyond technology's 'physical world limits', that is the drone's technological capabilities and capacities. Here, workplace regulations inform working arrangements for its operation, and thus become part of and limit its inscribed capacities and *intended effect*, that is to replace workers.

Drones and the 'effects' on work

As indicated, the *intended* and *direct effect* of drone technology is to facilitate monitoring by easing access (e.g. to chimneys, roofs and pipes) and allow for work to be conducted in more efficient ways. The latter outcome seems questionable, but as another *intended effect* work might become safer. As a feature of the steel industry environment, health and safety has a high priority and, as an *intended effect*, drones might be regarded as just one further incremental feature of OHS protocols and measures (Nordlöf *et al.*, 2015)—signalling, in this way, some level of continuity, rather than *discontinuity*, with wider organisational/sector practices. In both Germany and Italy, workers identified the benefits of reducing the need to work at height:

Sometimes we go up there, we don't know the situation of the structure is old and there is a risk of falling.

(Roof Inspection, Roofer, Section Leader, SteelCo.IT)

But, the technology also introduces new safety concerns, which indicates some level of *discontinuity* with regard to workers' current experiences of safely conducting monitoring tasks. This is an *unintended effect*, that is the technology is deployed to improve safety but, in its use, unintentionally introduces the potential for accidents:

...the drone is flying above, and you need to keep an eye on it, it means that you have to have one eye pointing above and one pointing below... So, I can imagine that this might actually increase the risk of accidents.

(Works Council, Maintenance Engineer, Section Leader, SteelCo.DE)

Further, if work intensification is an *indirect effect* of drone insertion it might also compromise safety and negate any safety gains made, that is as workers succumb to pressures to work harder errors may creep in and compromise safety. But, overall, as an *intended effect*, the substitution of workers with drones for reasons of OHS seemingly represents a basis upon which workers embrace the new technology—the benefits

viewed to outweigh any new risks. At the same time, however, questions were raised by our interviewees on the extent to which workers' enhanced safety might compromise work processes and workers' embodied skill sets.

The general consensus across the plants is that drones will not replace human maintenance and monitoring inspections without some information loss—essentially the *direct effect* of losing the worker's presence (i.e. substituted by a drone) would be the *unintended effect* of 'deskilling' some aspects of operations, with the potential loss of experienced workers' embodied knowledge (see MacKenzie *et al.*, 2017: 742 on related themes). Interviewees at both sites caveated workers' embrace of the drone technology by pointing out that embodied expertise and tacit knowledge, the ability to relate senses such as touch or sound, cannot be entirely substituted by drones equipped with thermographs or cameras:

Well, you develop a feel, for example you develop a feel for noises that are related to leaks... But someone who has never done that walks along the same path [and] they might not even notice the noise... you can develop a feel for this over time.

(Service Division, Maintenance Engineer, Team Leader, SteelCo.DE)

The fact that the work is embodied, that is carried out by a human being in conjunction with the physical realities of the plant, means that the current inspection regimes have a range of characteristics that drones are unable to replicate in their replacement of workers—it is against this that any safety and efficiency gains (i.e. benefits) are measured by workers.

Added to such deliberations is the view at both plants that automation and the introduction of new technology will create, in formal ways, a higher skilled workforce. It is a perspective that supports the views of those commentators, steel industry specific and otherwise, who suggest that emerging digital technologies will support higher skilled jobs for some (Naujok and Stamm, 2017) and necessitate negotiations on training, unless the skills are recruited or outsourced:

The use of very modern machines requires from our maintenance point of view.... better training, because there are some things you can learn from experience, but these are more dedicated things, so you need better [specialised] training...

(Cold Rolling Mill, Maintenance Engineer, Section Leader, SteelCo.IT)

At the time of the research, it was unclear who exactly will need training and how intensive such training needs to be (depending on the precise way drones are to be inserted), and as predicted some (lesser skilled) workers may well miss out (Naujok and Stamm, 2017). However, UAV-based gas pipeline monitoring will require new IT and data analysis skills and it is a legal requirement to obtain a pilot's licence for drone operation at both plants. Our technical-maintenance workers in Germany and Italy thus spoke positively about the benefits that might derive from drone use to the individual, that is safer, upskilled work and, in this way, expressed some ownership over the forces of production, with such perspectives relating to the more extensive range of potential drone uses identified by our interviewees, in addition to pipe, roof and chimney monitoring. The *direct* 'effect' of drones seems desirable, but fuller consideration also needs to be given to understanding drone 'effects' as a means for asserting managerial control, for example intensification, as discussed above, and heightened surveillance, as next discussed.

Currently, fixed cameras are used in both plants, but do not follow workers and workers' informed consent was required before the cameras were placed. In Germany, CCTV monitoring remains controversial and the Works Council has considerable say over the way such technology is introduced. Similarly, in Italy, all of the interviewees were very clear that legislation prohibits focusing cameras on people and filming them at their work: 'It is not allowed here, you cannot film people working'. However, if surveillance for maintenance purposes is the *intended* and *direct effect* of the drone technology, we might anticipate the *unintended effect* of exposing workers to higher degrees

of surveillance from drones. Drone surveillance can take two forms: (i) direct observation of workers at their work, which at both sites data protection regulation prevents (as for CCTV), and (ii) increased surveillance of workers by means of the data generated from a wider array of sensors and software. The former represents a *reconstitution in use*, in the nature and application of surveillance technology, that is fixed cameras are used routinely, but drone cameras potentially allow for *reconstitution in use*, in their mobility and the extent and coverage of the visual data produced—a major obstacle to their use for the Works Council in Germany.

The sensor data would seem to allow for increased monitoring of the scope, scale and intensity of work conducted, that is dataveillance (Lupton, 2016). The generation of a 'data-trail' is an *indirect effect* that has yet to be fully considered by workers and their representatives. Certainly, as new technologies emerge, workers might question whether current data protection provisions remain fit for purpose. The threat is that digital technologies may display 'function creep' (Lupton, 2016). Thus, whilst workers may consent to drones and the gathering of data, if the data gathered are used for other purposes (e.g. performance management), the initial consent may never have been given. Currently, data protection regulations exist to protect workers from direct observation of their work activities and maintain dignity at work, but the scope for enhanced monitoring through technological surveillance, or 'dataveillance', becomes apparent (*c.f.* digital Taylorism). The generated data create space for evaluating performance with a view to optimisation, competition and control. It is with such risks in mind that we next examine, as far as our data permits, worker representation in relation to the more deleterious 'effects' of drone technology.

Worker representation and participative arrangements

Edwards and Ramirez (2016) suggest that Industry 4.0 technologies possess the capacity to empower workers, but for this to be realised workers their representatives must first understand the 'effects' of emerging technologies. There are, however, different foundations and distinct traditions regarding the shape and form of participative arrangements at our plants in Germany and Italy, which reflect more broadly distinctive institutional frameworks and, in a more specific sense, structures and strategies of industrial relations and workplace governance and democracy within each site (see Lloyd and Payne, 2019). It is within the frame of such differences that the extent to which drone technologies possess the capacity for dis/empowerment can be discussed.

In Germany, it was evident that the role of the SteelCo.DE Works Council is significant in the introduction of new technologies. Under the firm's rules of participatory governance, the RFCS project was subject to Works Council approval, but it became apparent that only management was consulted about the project. The Works Council had the right to veto the project (and drone use) and, at first, did so. The main worry was procedural, that is setting an unwanted precedent of non-consultation, but there was also disquiet regarding technology 'effects', for example substituting workers, workforce surveillance and new safety concerns. Eventually, the Works Council granted project approval on safety considerations, understood as a *direct effect* and clear benefit. Approval resulted in a *Betriebsvereinbarung*—a factory agreement—that outlines permissible usages of drones. Further, SteelCo.DE must inform the Works Council about all new applications and usages, and a more extensive approval process will be required if a new use for drones is proposed that differs substantially from previous uses (e.g. a new use would be 'surveillance of people' whilst 'monitoring coke oven gas pipelines' would constitute the extension of an approved use).

The Works Council is clearly active on decision-making when introducing new technologies, considering its 'effects' in terms threats to jobs, dignity at work (i.e. surveillance) and safety. It can shape, if not prohibit, the insertion of technologies and is

focused on the 'effects' vis-à-vis risks and benefits. Here, it seems, strong corporate or coordinated arrangements facilitate the incremental integration of technological innovation (Hall and Soskice, 2001), which provides for workers' more trust-based engagement. Certainly, the way drone technology is being introduced, that is on a case-by-case basis, suggests an incremental approach—even if the technology itself provides for some level of *discontinuity* and might otherwise be regarded as 'radical'. Further, whilst the role of the main trade union at the plant, IG Metall, was not remarked upon by our interviewees and we did not have the opportunity to interview union officials at the plant, lessons from elsewhere suggest similarly cautious approaches from the union to managing innovation (Reuter *et al.*, 2017). And yet, our HR representatives reported on firm strategies to circumvent negotiations with IG Metall on the integration of digital skills to the existing workforce, by focusing on initial training provision (i.e. apprenticeships), rather than continuing vocational training, as well as insisting that drone-related upskilling will not translate into higher wages. Embedded within industrial corporatism, IG Metall's traditional position of strength on such matters relies on high union densities, strong works councils and substantial disruptive potential, but over successive financial crises its power resource has tended to wax and wane, the corollary of which is heightened employer confidence and increasing deviations from sectoral collective agreements (Dribbusch *et al.*, 2018)—some evidence of which might be seen here.

At the site in Italy, we could not access the trade unions nor the *rappresentanze sindacali unitarie* (i.e. Works Council), which is mostly dominated by the trade union *Unione Italiana del Lavoro* (UIL). However, in terms of representation it is noted that union density is high at the plant and all interviewees spoke of the need to consult with plant trade unions and seek agreement over the introduction of new technology. This was not perceived as an insurmountable issue—the unions had previously accepted cameras and robotics in certain plant areas. However, the relationship between management and unions is, as already commented, difficult. Whilst consultation might be made on the insertion of technology, our interviewees suggested some potential for worker and union resistance (which in Germany was not mentioned). Concerns about the risks of drones were generally attributed to the recalcitrance of some individuals, who tended to complain about everything: 'One or two might object, but that's because they object about everything!' [Galvanising, Maintenance Engineer, Section Leader, SteelCo.IT]. All of our interviewees believed that if people were educated about the need for such innovations, they would generally be accepting—pointing out that if the use of drones (*direct effects*) was linked to positive outcomes, like enhanced safety, they would be received positively. Of course, as commentary from higher skilled workers, what is perhaps reflected is their greater job security (Brynjolfsson and McAfee, 2014), with these same interviewees identifying production workers as most likely to fear and resist change, although it was stated that some technical staff also dislike change as 'innovation brings risk' [Steel Shop, Team Leader, Maintenance Engineer, SteelCo.IT].

However, a more significant barrier to technological innovation was viewed to be poor managerial attitudes. Some of the workers interviewed have long been highly proactive in recommending drone technology and recognise the 'feasibility of the technology' and its likely high *degree of success* (Edwards and Ramirez, 2016), but they spoke of management's hesitancy and prevarication:

When we suggested the drone applications, [management] weren't interested... They will invest in particular equipment for production... that's ok to spend but for new technology like this... that's another matter.

(Cold Rolling Mill, Systems Engineer, Section Leader, SteelCo.IT)

Opposition is blamed on a strong productivist ethos, characterised by short-term orientations associated with managerial predilections for centralised modes of control and unilateral decision-making ethos (despite claims to consultation), which entails

that production must take priority and overrides other considerations—an economic consideration in terms of *degree of success*, but not in ways anticipated by Edwards and Ramirez as a ‘means of accumulation for capital’ (2016: 110):

Every project we have or would like to start – the first question is always cost-benefit analysis; how much will it save? The priority is production. We have to run the plant first of all, then the innovation projects.

(Steel Shop, Maintenance Engineer, Team Leader, SteelCo.IT)

There was clear frustration with plant management, where a ‘productivist ethos’ prevented the insertion of technologies, such as drones, which might improve safety and enhance work. The capacity of unions or the works council to empower workers in this regard seems highly circumscribed and follows what Culpepper and Regan (2014) identify as a tendency towards reduced trade union influence in Italy, with the basis for organised responses diminished. On this, Hyman (2001: 155) notes that Italian trade unions were once characterised by ‘productivism’, with strong rights to control over production and sharing with management decision-making (e.g. on work organisation, competitive challenges, innovation), but this has been eroded—informed by challenges within the working-class constituency, resulting in declining density (not the case here), and greater self-interest among skilled groups, which may begin to explain (anticipated) objections from some (less skilled production) workers to drone technologies. Thus, whilst the benefits of drone use are articulated quite clearly in Italy among those we interviewed, a broader absence of strong coordinated arrangements may weaken any ability to challenge management and mobilise against any emerging (Industry 4.0) threats and risks or, indeed, push for innovation insertion.

Discussion and conclusion

Drones are a powerful and innovative technology, but we can only speculate on whether they will be deployed systematically and with what specific ‘effects’ on work and employment—this is what we asked of our interviewees: anticipate the introduction of drones and determine the ‘effects’, with regard to potential risks and benefits, as understood within the context of steel industry workplace structures, tasks and routines. From this, we ask: on what basis might these intermediate to highly skilled technical-maintenance steelworkers embrace or resist new drone technology? To begin to address this question, and working from arguments that suggest management has a propensity to use technology as a means for strengthening control, we might imagine that steel industry employers would view digital technologies, like drones, as a means for workforce reductions, heightened surveillance and increased work intensification. This is in line with the RFCS project’s aims for enhanced productivity and efficiency in ‘complex and expensive operations’. The evidence is that to greater or lesser degrees such potentialities exist.

However, the workplace realities described by our interviewees make drone insertion highly contingent and these technical-maintenance workers possess relatively optimistic outlooks on the *(un)intended* and *(in)direct effects* of drone technology. Hence, what we first discuss is a challenge to the narratives that treat digital technologies and the risks they present as inevitable and determining. In the assessment of drone technology ‘effects’, it is necessary to consider the capacities (e.g. greater autonomy and discretion) that these intermediate/high-skilled workers have to shape (or imagine) the use of technology to their benefit, within the specificities of the steel industry workplace. The reference here is to the basis upon which these workers accept innovations and their ‘effects’ (e.g. the capacity for upskilling and enhanced safety), when set against the risks posed (e.g. job loss, heightened surveillance, work intensification, deskilling) and the basis upon which workers and their representatives might question the insertion of innovations, as did the Works Council in Germany.

Here, the issue of job loss was not viewed as a plausible risk, seeming unlikely in these understaffed factories. In contrast to industry predictions, the scope is for increased recruitment as an *unintended effect*, even for routine manual work (Naujok and Stamm, 2017). Further, any loss of embodied skill, or deskilling, is anticipated to be balanced by the need for technology induced upskilling, as a *direct effect*. There remain, however, 'effects' not hitherto fully appreciated by our interviewees, which may yet inform future opposition to/negotiations for drone innovation insertion. For example, in the absence of recruitment, intensification is a real possibility, which if realised may threaten any OHS gains as workers become overstretched. On surveillance, our interviewees (and their representatives) find reassurance in data protection regulation, but the regulations might no longer be fit for purpose—the function creep of technology is an *unintended effect* that is difficult to guard against.

Nonetheless, our interviewees do not view themselves as hostages to drone technology 'effects'. Despite the volatility of the steel industry and its myriad uncertainties, such outlooks in relation to new digital technologies will be informed by these skilled workers' past experiences on what costs jobs and what does not, particularly relating to *discontinuity* (i.e. levels of disruption) and *degrees of success* (i.e. the technology's efficacy and the negotiation of its adoption). In this respect, our workers' perspectives may well convey an accurate view of the skill- and work-related *effects* and demands made by new workplace technologies (Autor, 2015). Thus, for our technical-maintenance workers, the question is of what it means to be a technically skilled and autonomous steelworker, with the codified and embodied knowledge they possess (Polanyi, 1966). What we find is that these workers seem sufficiently secure in the material realities of their skilled status and skilled work, to welcome technological innovation and its 'effects'—this might not always be said with the same confidence for (or by) those performing routine manual work, but as indicated the scope for further workforce reductions in these plants seems limited (particularly if a firm prioritises production over innovation, as in Italy).

The point is made by Pfeiffer (2017: 31) that Industry 4.0 is meant to change the way we work, but it is a model that demands a high willingness of workers (and their representatives) to cooperate with management, which brings us to our second observation concerning collective responses to technology 'effects'. Here, it is necessary to consider socio-political choices and the role of participative arrangements, as a reflection of power and interests, in shaping whether, and in what ways, digital technology is inserted in the workplace—and from the workers' perspective how capacity is focused on addressing the more deleterious 'effects' of technology. The critical question for our interviewees is the extent to which participative arrangements, in this highly collectivised industry, strengthen any ability to mobilise against emerging threats and risks, that is prevent the use of drones as a tool of atomisation and control, and allow for democratic debate and collective discussion on the insertion of the 'digitalised artefact(s) of advancement' (see Pfeiffer, 2017).

What we observe is that the strong corporatist arrangements in Germany and the role of the Works Council seemingly give greater scope for this and workers in this plant perhaps speak with more confidence on innovation—despite some evidence that management seeks to exploit any decline in IG Metall's power resource (see Dribbusch *et al.*, 2018). In Italy, consultation on innovation is claimed but the industrial relations environment seems difficult and fractured. Hence, despite our interviewees being positively inclined towards drones, a 'productivist ethos' informs technology decisions and there is little evidence that drones will be introduced at all, let alone in ways that positively enhance the material realities of employment. Further, unlike in Germany, our participants described potential cleavages along occupational-skilled lines (intermediate and high-skilled workers vs. production worker grades) on technology insertion (see Hyman, 2001), which renders innovation insertion contingent upon the way the labour process and the political apparatus of production coalesce for particular categories of worker (Burawoy, 1985).

What is articulated here is the differing fortunes of different categories of worker. Ultimately, the manner of technology insertion and the response to technology 'effects'

will be shaped by the interests, values, and visions prevailing in the workplace and the specificities of the institutional and industrial relations context that helps define them. Pfeiffer (2017: 33–35) speaks bleakly of Industry 4.0 and the capacity of labour to employ digitalised artefacts as ‘instruments of collective solidarity’, and suggests a convergence towards ‘digital despotism’, with the likely hollowing out of labour rights and the democratic potential of industrial relations. But it is perhaps too early in the emergence of Industry 4.0 technologies to be definitive on Pfeiffer’s analysis and something of a challenge to it emerges out of the lens we have adopted. Our focus is on technical-maintenance worker perspectives on technology ‘effects’ and the deliberations they make on the inherent tensions within digital technology, that is for more decentralised and autonomous work on the one hand, as these workers envisage, and digitised instruments of atomisation and control on the other, of which—admittedly—the potential exists, but the likelihood is far from certain.

Thus, whilst the RFCS project promises a safer, faster, leaner steel industry, the question our steelworkers have considered is whether this direction of travel involves enhancing or diminishing the material realities of their work and employment. What we know is that workers have a natural interest in their work being something that enriches rather than degrades them (Spencer, 2018), and the frequency with which the benefits from drones were highlighted as strong justifications for their use is testimony to this—it is the basis for their acceptance—and on this, it is perhaps, that workers recognise that it is not the machinery (*effect*) itself that threatens them.

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